# Internal Waves Over the New England Shelf

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## LONG-TERM GOALS

Our long-term goal is to better understand processes controlling the horizontal and vertical distribution of internal wave energy over the continental shelf. Emphasis is placed on the near-inertial band. Both the initial response to impulsive forcing and the overall distribution of near-inertial energy are of interest.

## OBJECTIVES

We will investigate several aspects of the internal wave field over the New England Shelf, considered to be representative of a general class of broad, gently-sloping shelves. Specifically, we intend to characterize the horizontal and vertical structure of the internal wave field over the shelf and examine the near-inertial response to impulsive wind forcing.

## APPROACH

Data from the Nantucket Shoals Flux Experiment (NSFE) and the combined Coastal Mixing and Optics (CMO) and Shelf Break PRIMER experiments will be used to document characteristics of near-inertial waves. Surface forcing fields will be examined to identify events that evoke strong near-inertial responses. Analytical models based on the two-layer formulations of Pettigrew (1980) and Millot and Crepon (1981) will be used as a guide to interpreting the observations. If the observed stratification warrants the additional complexity, a continuously stratified model (Kundu et al., 1983) will be employed. A two-dimensional, nonlinear numerical model will be used to investigate the mechanisms controlling the cross-shelf structure of near-inertial energy. This work will follow that of Federiuk and Allan (1996) and Chen and Xie (1997). The intent is to incorporate surface forcing, cross-shelf topography, and stratification which is more realistic than that of the analytical models.

## WORK COMPLETED

The near-inertial signal was isolated from the CMO current meter data by removing the dominant barotropic tidal constituents and band-pass filtering the resulting record. Aspects of surface forcing relevant to analytical modeling (front translation speeds, storm sizes, translation speeds and durations) were determined for CMO/PRIMER using the buoy meteorology and the regional model results described by Baumgartner and Anderson (1999). Two-layer analytical models were used to explore the oceanic response for a variety of model parameters. There are three models distinguished by the type of forcing: Impulsive forcing (delta function) as described by Pettigrew (1980), propagating step function forcing (representing the leading edge of a front) and propagating pulse forcing (representing the leading and trailing edges of a storm system).

## RESULTS

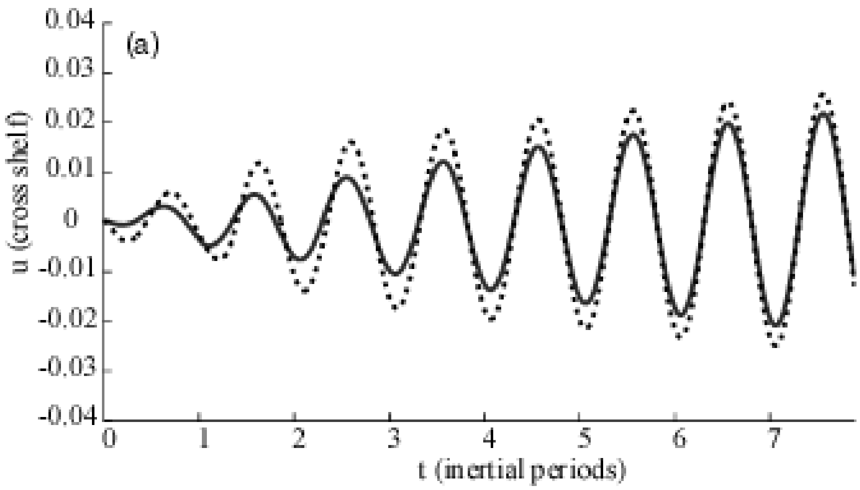
Initial model runs concentrated on simulating storm fronts with offshore translation (cf., Kundu and Thompson, 1985). However, for realistic translation speeds these runs always showed upper and lower layer responses which were nearly in-phase (Figure 1a). In contrast, the majority of the observed responses showed the upper and lower layers nearly out of phase. The regional meteorological model fields provided an answer - most wind events during CMO propagated rapidly alongshore, rather than offshore, and appeared at a given along-shelf location as a nearly instantaneous pulse across the entire shelf. Modifying the forcing to represent a cross-shelf uniform pulse of finite duration (by using an infinitely fast cross-shelf translation speed) showed an out of phase response more similar to the observations (Figure 1b). As might be anticipated, the amplitude response for the cross-shelf uniform, finite-duration pulse is strongly dependent on the pulse duration relative to the local inertial period. Pulses lasting an integral number of inertial periods produce a highly damped near-inertial response due to destructive interference between waves generated by the leading and trailing edge 'fronts'. In contrast, pulses lasting half an inertial period produce constructive interference and correspondingly strong near-inertial motions. Observed CMO wind events also exhibited considerable rotation, a characteristic not accounted for in these simple models. Thus, care is warranted when making direct comparisons between observed and modeled near-inertial responses.

## IMPACT/APPLICATIONS

By extending both analytical and numerical work done by previous investigators, we hope to elucidate the principal processes which control the near-inertial response on broad, shallow shelves. Through comparison with observations the ability of simple two-layer models and more complex numerical models to reproduce the observed response will be evaluated.

## TRANSITIONS

None.



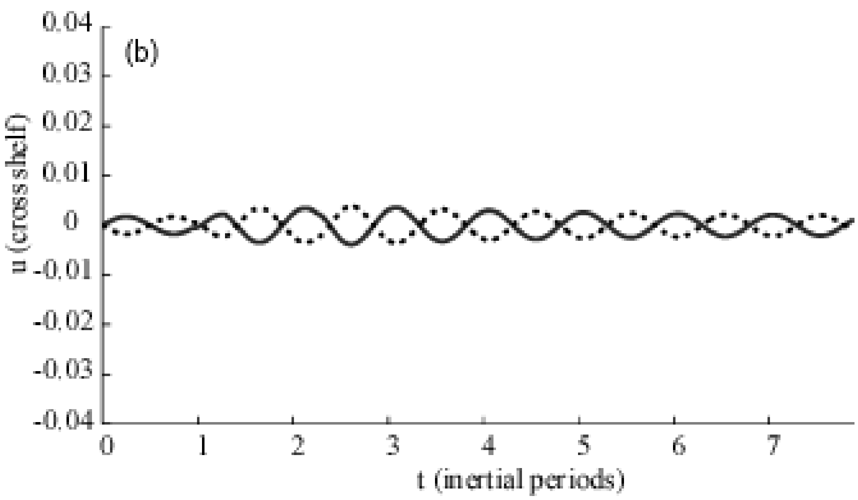




***Figure 1: Velocity response of the upper (solid) and lower (dashed) layer for an analytical model with forcing by an offshore-translating pulse of duration 1.3 times the inertial period. Layers are of equal thickness with barotropic (baroclinic) wave speed of 24.2 (0.4) m/s. Results are for a location six internal Rossby radii from the coastal boundary. Two different pulse configurations are shown: (a) offshore translation at 15 m/s, (b) instantaneous occurrence over the entire cross-shelf domain (infinite translation speed).***

## RELATED PROJECTS

We are using archived data from NSFE (supported by the National Marine Fisheries Service, the U.S. Geological Survey, and the National Science Foundation) and recently acquired data from the CMO moored array and the Shelfbreak PRIMER experiment (funded by the Office of Naval Research (ONR)). We are sharing data and results with M. Levine and T. Boyd at Oregon State University who are funded by ONR to investigate the coastal internal wave field.

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